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TRANSLATION FROM JAPANESE

(19) JAPANESE PATENT OFFICE (JP)
(11) Japanese Laid-Open Patent Application (Kokai) No. 63-140904
(12) Official Gazette for Laid-Open Patent Applications (A)

(51) Int. Cl.⁴:		Classification Symbols:	Internal Office Registration Nos.:
G 01 B	11/00		Z-7625-2F
	11/30	102	Z-8304-2F

(43) Laying-Open Date: June 13, 1988
Request for Examination: Not yet submitted
Number of Inventions: 1
(Total of 4 pages [in original])

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(54) Title of the Invention: Scattered Light Measuring Instrument

(21) Application No. 61-289288
(22) Filing Date: December 4, 1986
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SPECIFICATION

1. Title of the Invention

Scattered Light Measuring Instrument

2. Claims

1. A scattered light measuring instrument, characterized by comprising a light source; an optical system for focusing light from this light source and directing it toward a measurement object; a tubular body having on its inside surface a reflecting surface for receiving scattered light from the aforementioned measurement object and configured in such a way that it encircles the emitting side of this optical system; a photoelectric converter for performing photoelectric conversion on the scattered light from this tubular body; and a processor for processing the output from this photoelectric converter.

2. A scattered light measuring instrument as defined in Claim 1, characterized by the fact that the photoelectric converter is composed of a split sensor or a multipixel image sensor.

3. A scattered light measuring instrument as defined in Claim 1, characterized by the fact that the photoelectric converter receives scattered light together with specularly reflected light.

3. Detailed Description of the Invention

Field of Industrial Utilization

This invention relates to a scattered light measuring instrument for measuring a measurement object on the basis of scattered light generated after light strikes the measurement object.

Prior Art

A particle diameter or the surface pattern of a measurement object is measured using scattered light generated when light strikes the measurement object.

Examples of conventional scattered light measuring instruments used for such measurements include those in which a sphere *c* encircling a particle or other

measurement object *a* is placed in the light path *b* of light striking the measurement object *a*, as shown in Figure 6, and measurement is performed by integrating scattered light [beams] *d* received by the inside surface of this sphere *c*; those in which scattered light [beams] *d* from a measurement object *a* are received by a photodetector *f* via a lens *e*, as shown in Figures 7 and 8; and those in which a parabolic mirror *Q* for receiving scattered light [beams] *d* is provided on one side of a light path *b*, a photodetector *h* is placed opposite the parabolic mirror *Q*, and the scattered light [beams] *d* are measured in conjunction with the operation of a photodetector *f* in the light path *b*, as shown in Figure 9.

Problems Which the Invention Is Intended to Solve

The measurement technique involving the use of integrating spheres, while capable of detecting all scattered light, is disadvantageous in that the angular distribution of scattered light cannot be measured. In addition, the structure in which scattered light [beams] *d* are guided toward the photodetector *f* using an optical system (lens *e*), while good when the scattering angle θ is small, is difficult to use when an attempt is made to measure a large scattering angle θ, because in this case a lens *e* having an extremely large aperture must be used or the lens *e* must be placed very close to the measurement object *a*. A drawback of the structure involving the use of a reflecting mirror (parabolic mirror *f* [sic]) is that the apparatus itself is bulky. Thus, none of the above structures is advantageous.

An object of this invention, which was devised in view of such drawbacks, is to offer a compact scattered light measuring instrument capable of measuring the scattering distribution of scattered light and scattered light of considerable scattering angle without the need for using a large aperture or substantially reducing the distance from the measurement object.

<u>Structure of the Invention</u>

Means Used to Solve the Above-Mentioned Problems, and Effect Thereof

In this invention, an optical system 3 is provided for focusing light from a light source 2 and directing it toward a measurement object 1; a tubular body 6 having a reflecting surface 6a on its inside surface is provided for encircling the emitting side of this optical system 3, so that scattered light from the measurement object 1 is received;

scattered light from the tubular body 6 is subjected to photoelectric conversion by a photoelectric converter 8; and the output thereof is processed.

Practical Examples

This invention will now be described based on the first practical example illustrated in Figures 1 through 3. Figure 1 depicts a schematic structure of the scattered light measuring instrument. 1 is a measurement object with a flat top surface, 2 is a light source whose emitting unit is directed crosswise above said measurement object 1, and 3 is an optical system. The optical system 3 is configured in such a way that in addition to it being provided with a condenser 4 immediately above the measurement object 1, a beam splitter 5 is placed between this condenser 4 and the emitting unit of the light source 3 [sic]. [The system] is designed to focus light coming from the light source 2 and to guide it toward the surface 1a of the measurement object 1.

The condenser 4 is enclosed in a tubular body 6 whose shape resembles that of a bowl such as that shown in Figure 3. The tubular body 6 is oriented along the light path in such a way that the smaller opening is close to the surface 1a of the measurement object 1. A reflecting surface 6a composed of a mirror surface forms the inner surface, and scattered light A scattered by the surface of the measurement object 1 is transmitted through the smaller opening and received by the reflecting surface 6a. A stopper 7 for blocking specularly reflected light is mounted on the back of the beam splitter 5, yielding a structure in which only the scattered light A from the larger opening of the tubular body 6 can be emitted.

As shown in Figure 2, a photoelectric converter such as an area array sensor 8 (multipixel image sensor, photodetector) is installed on the emitting unit side (larger opening side) of such a tubular body 6 in a direction that is at a right angle to the axis of the tubular body 6, allowing scattered light A to be selected from a distribution shaped as concentric circles. A processing circuit 9 (corresponds to a processor) composed of a microcomputer is connected to this area array sensor 8 to allow total scattered light, scattering angle distribution, scattering solid angle distribution, and other parameters needed for pattern detection to be determined based on the electric signals of the resulting scattered light distribution.

The operation of the scattered light measuring instrument thus configured will now be described.

When the light source 2 is energized, light emitted by the light source 2 is guided toward the lens by the beam splitter 5, gathered by the condenser 4, and directed toward the surface 1a of the measurement object 1. This results in reflection from the surface 1a and in the generation of specularly reflected light and scattered light A corresponding to the (constant) pattern to be measured on the surface 1a.

The path of the specularly reflected portion of the reflected light is blocked by the stopper 7, and scattered light A is reflected toward the reflecting surface 6a and guided toward the surface of the area array sensor 8 together with the scattered light A that has passed through the circumferential peripheral portion of the condenser 4. As a result, scattered light A strikes the sensor surface while describing concentric circles, and detection involves not only [light] from the condenser 4 but also scattered light A having a large scattering angle.

When total scattered light A is to be detected, the combined light detection area of the sensor surface should be determined with the aid of the processing circuit 9, and when the distribution of the scattering angle is to be detected, the sum of circles on the same radius should be determined with the aid of the processing circuit 9, or, in the case of the distribution of the scattering solid angle, the sum of circular arcs that are at the same angle should be determined with the aid of the processing circuit 9.

This allows scattered light A having a large scattering angle to be measured without using a lens with a large aperture or placing the lens very close to the measurement object 1. Apparently, the angular distribution of scattered light can also be measured. Another advantage is that in addition to the fact that a tubular body 6 encircles the optical system 3, an area array sensor 8 may be installed near the rim of the opening in the tubular body 6, and that the resulting device is compact in comparison with a bulky conventional device in which a reflecting mirror is installed on the incident side.

Although the first practical example refers to a case in which the scattered light A alone is detected, it is also possible to remove the stopper 7 and to detect specularly reflected light together with the scattered light A.

— large particles

not small

not focused, no slope.

The first practical example refers to a case in which a constant pattern is detected on the surface 1a of the measurement object 1, but this is not the only option. It is also possible to ~~create~~ cause a flow of particles (not shown) instead of the measurement object 1 and to measure the particle diameter or the like on the basis of the distribution of the scattering angle (particle measurement).

Although the first practical example involves the use of an area array sensor 8, it is also possible to determine only the distribution of the scattering angle of scattered light using a linear array sensor 10, as in the second practical example illustrated in Figure 4, or to determine the distribution of the solid angle of scattered light using a split sensor 11 divided into four parts, as in the third practical example illustrated in Figure 5.

The first practical example involves the use of a tubular body 6 shaped as a bowl, but this is not the only option. The tubular body may have a cylindrical, conical, or other shape. It is apparent that a split tubular body may be used and that this is not the only possible structure.

Merits of the Invention

As described above, this invention allows scattered light with a large scattering angle to be measured without using a large aperture or significantly reducing the distance from the measurement object. It is also possible to measure the angular distribution of scattered light. Another advantage is that the device is compact and that a high-performance scattered light measuring instrument can be offered.

4. Brief Description of the Drawings

Figure 1 is a cross section showing the scattered light measuring instrument pertaining to a first practical example of this invention, Figure 2 is a plan view showing the photoelectric converter thereof, Figure 3 is a perspective view showing the tubular body thereof, Figure 4 is a plan view showing a second practical example of this invention, Figure 5 is a plan view showing a third practical example of this invention, and Figures 6 through 9 are side views of various conventional scattered light measuring instruments.

1: measurement object, 2: light source, 6: tubular body, 8: area array sensor (photoelectric converter), 9: processing circuit (processing unit), A: scattered light

light Source

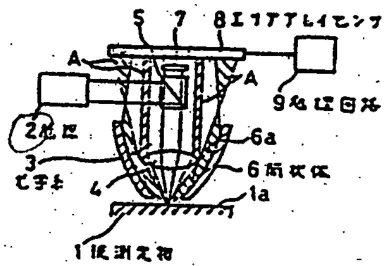

Figure 1
(Key 1: measurement object, 2: light source, 3: optical system, 6: tubular body, 8: area array sensor, 9: processing circuit)

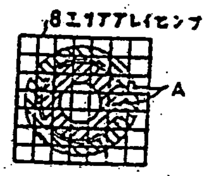

Figure 2
(Key 8: area array sensor)

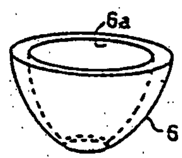

Figure 3

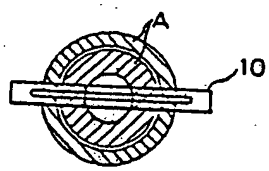

Figure 4

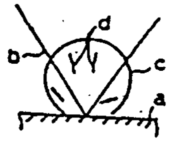

Figure 6

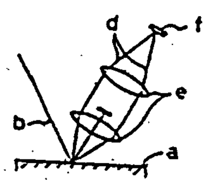

Figure 7

does not help to failure may help to surface defect: point in a direction

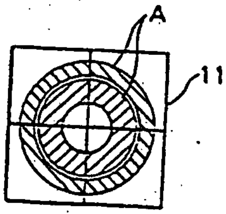

Figure 5

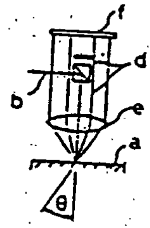

Figure 8

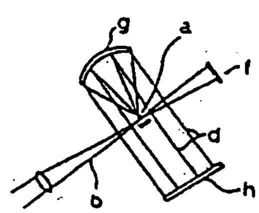

Figure 9